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FILED 5216T-07

REFERENCE #2  
SITE NAME SE ROCKFORD  
SITE ID ILD981000417

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DEPARTMENT OF REGISTRATION AND EDUCATION

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1960

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# GROUND-WATER GEOLOGY OF WINNEBAGO COUNTY, ILLINOIS

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REFERENCE 10  
SITE NAME SAND PARK LANDFILL  
SITE ID ILD980606693

REPORT OF INVESTIGATIONS 213

ILLINOIS STATE GEOLOGICAL SURVEY

JOHN C. FRYE, Chief

URBANA, ILLINOIS

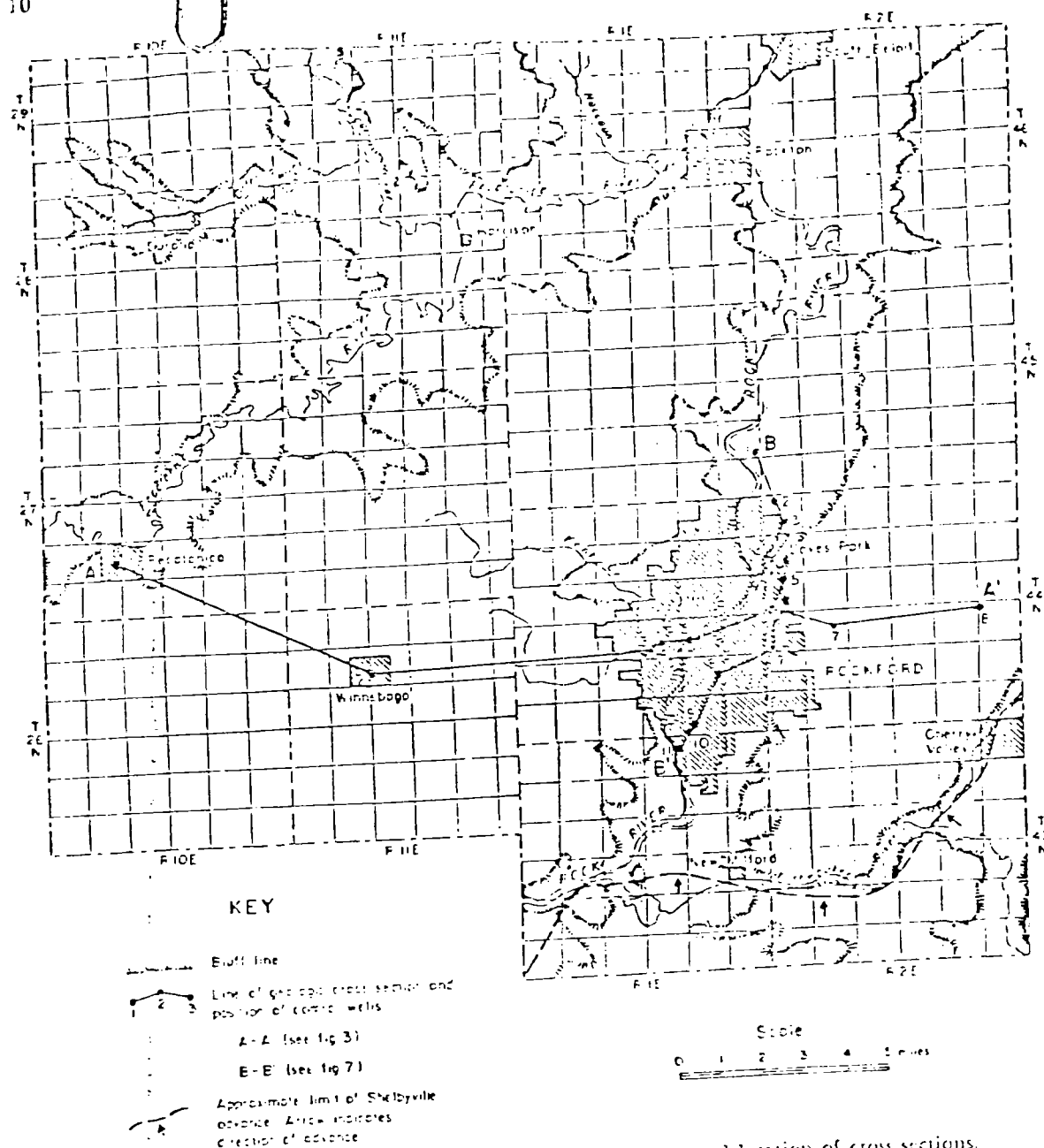


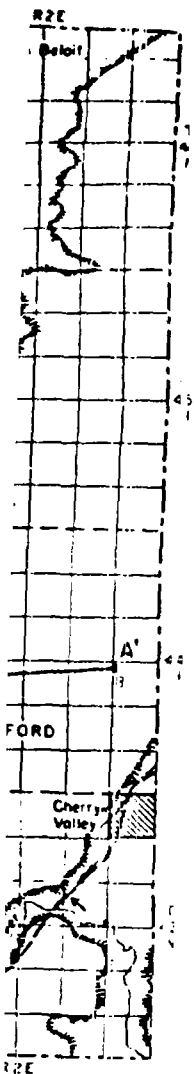
FIG. 2.—Principal geographic features of Winnabago County and location of cross sections.

the region, are the most outstanding features of the landscape and require separate description.

#### ROCK RIVER VALLEY

The Rock River enters the county from Wisconsin at South Beloit and flows generally southward within the eastern half of the county (fig. 2). North of the village of

Rockton the river flows through a broad lowland more than 8 miles wide along the north county line. Southeast of Rockton the lowland gradually narrows until it becomes a river valley only 2 to 3 miles wide and continues thus for about 6 miles in the direction of Rockford. Near Rockford, the valley again narrows and in the northern part of the city is constricted to a width of



less than one-half mile. In the central and southern part of Rockford, the valley widens until it again is 2 to 3 miles wide.

Near its junction with the Kishwaukee River, the Rock River swings southwestward and abandons its broad valley to leave the county in a narrow rock-walled channel only slightly wider than the river. The broad, alluviated, and abandoned lowland continues southward from the junction and ends abruptly against morainal deposits just south of the county line.

The Rock River Valley is characterized not only by its variable width but by a relatively narrow floodplain. Between the floodplain and the valley walls, glacial outwash deposits of sand and gravel occur in terraces, in most places 40 to 50 feet above the level of the river. In the wider reaches of the valley, the terraces are broad and continuous and at places occupy more than 80 percent of the valley area. Along the valley from South Beloit to the junction of the Kishwaukee River numerous pits have been opened into these terraces for removal of sand and gravel.

#### PECATONICA RIVER VALLEY

The Pecatonica River enters Winnebago County just west of Pecatonica and flows northeastward to join the Rock River in the wide lowland near Rockton. In the western part of the county, southwest of the junction of the Pecatonica and Sugar Rivers near Harrison, the Pecatonica Valley is 1 to 2 miles wide. East of Harrison the valley widens to more than 2 miles (fig. 2).

The Pecatonica and Sugar River Valleys are characterized by a broad floodplain reaching from valley wall to valley wall. Over these broad bottomlands the Pecatonica and Sugar Rivers follow a sluggish, complicated course of numerous tight meanders. The bottomlands are scarred by many abandoned meanders, some of which are oxbow lakes. The older oxbows have slowly filled with vegetation and sediment and many of them now form arcuate marshes. The wide floodplain and meandering streams of the Pecatonica and Sugar River Valleys are underlain by fine-grained sediments, whereas the extensive terraces

in the Rock River Valley are underlain by deposits of sand and gravel.

#### KISHWAUKEE RIVER VALLEY

The north and south branches of the Kishwaukee River enter southeastern Winnebago County and join in a large lowland about 2 miles west of the county line. At the junction the river enters a narrow rock-walled valley. At New Millford it leaves its narrow gorge to flow into the broad lowland that was abandoned by the Rock River. About 3 miles east of New Millford it joins the Rock River near the point where the Rock abandons its wider valley for a narrow rock-walled channel.

#### INDUSTRY

Winnebago County has a large industrial economy for which the availability of suitable ground-water supplies is an important element. The U. S. Bureau of the Census (1957, p. 112-5, 112-6, 112-18) reports that during 1954 there were 439 business establishments operating in Winnebago County, including the following major groups:

Industry group	Number of establishments
Machinery (except electrical) . . . . .	141
Fabricated metal products . . . . .	71
Food and kindred products . . . . .	43
Printing and publishing . . . . .	42
Furniture and fixtures . . . . .	22
Primary metal industries . . . . .	21
Stone, clay, and glass products . . . . .	13
Transportation equipment . . . . .	11

These establishments employed 38,194 persons in 1954, an increase of nearly 11 percent over the employment total for 1947, and their annual earnings totaled \$177,568,000. More than 92 percent of employees listed were employed in the city of Rockford and received annual pay of \$162,956,000.

The estimated amount added to the county's economy by manufactures in 1954 was \$312,770,000. Of the total number of persons employed, 29,318 were listed as production workers whose total annual wage was \$124,101,000.

lers. They may, however, store large quantities of ground water.

The sands and gravels of the outwash deposits range from very fine grained to very coarse grained, and the sorting ranges from excellent to poor. Glacial outwash deposits are characterized by many lateral and vertical changes in character and thickness, which result in corresponding variations in the transmissivity of the deposits. Test drilling preliminary to construction and development of medium or large capacity wells generally is necessary to 1) establish the presence of suitable aquifer material, 2) determine the most satisfactory well location in a material of varied character, 3) select the most permeable zone or zones for development, and 4) provide the information necessary for proper well design and construction.

Deposits of fine- to medium-grained silty sand of relatively low permeability occur in the valley fill. Much of the valley fill in the Pecatonica and Sugar Valleys and the upper portion of the fill in the ancient Rock Valley south of the Kishwaukee River contain extensive deposits of fine-grained outwash that is generally unsatisfactory for well development. The water in the sands generally is under hydrostatic head conditions that cause the material to be "quick" and considerable difficulties from caving or "running" sand are encountered during well construction.

In valleys where deposits of silt and clay underlie the valley floor, such as the Pecatonica and Sugar River Valleys, ground-water recharge to underlying glacial and bedrock aquifers and upward discharge of ground water from these aquifers is greatly restricted. In some valleys near-surface outwash may be separated from older valley fill outwash by widespread deposits of till of low permeability. The till retards the movement of ground water and may allow the development of a difference in the hydrostatic heads of the aquifers. In areas where the deeper aquifers are heavily developed, local recharge from the surface is restricted by this till.

Ice-contact sands and gravels that are extremely variable in texture and sorting are

scattered throughout the county. Some, such as the upland gravels in the vicinity of New Millford, occur as surficial deposits overlying glacial till. Other ice-contact deposits are interbedded within the till or occur on the sides of drainage valleys that contained stagnant ice blocks. Although the permeability of the deposits may be very high, the rapid changes in their character and thickness and their usually limited extent generally make them unsuitable for large-scale ground-water development. They may be excellent aquifers for small-capacity wells.

The till that blankets most of the uplands of Winnebago County contains a large proportion of fine-grained materials and is poorly sorted. The low permeability of the till prevents it from yielding economic amounts of water to drilled wells, but it may provide usable quantities of water to large-diameter dug or augered wells. Although water movement through the till is relatively slow, recharge into or discharge from adjacent aquifers does occur.

## GROUND WATER

### OCCURRENCE AND MOVEMENT

The vast reservoir of ground water that underlies Winnebago County is contained in sediments of Cambrian, Ordovician, and Pleistocene age. This reservoir is continually replenished by precipitation that falls on the land surface in and adjacent to the county and by streams flowing into the county. The amount of water stored in the ground-water reservoir depends on the amount and distribution of recharge from precipitation and streams; the thickness, extent, and porosity of the water-containing rocks; the recharge characteristics of the soil and surficial deposits; and the base-levels of ground-water discharge.

Recharge to, movement within, and discharge from the ground-water reservoir are complicated by variations in permeability between and within the reservoir rocks and by the relief and configuration of the land surface. Ground water generally moves from the uplands to the valleys, which are

the principal areas of discharge. In the glacial drift and shallow bedrock aquifers, ground-water movement is closely related to the configuration of the land surface. In the deeper lying sandstone aquifers, ground water moves from the higher land areas along the eastern and western borders of the county toward the low-lying valley of the Rock River (Smith and Larson, 1948, p. 15, fig. 3). Movement in other confined beds generally is from higher to lower land but not necessarily closely related to the surface configuration.

In the early investigations of the deep artesian aquifers of northern Illinois it was assumed that the source of recharge to the deep sandstone aquifers was in central and southern Wisconsin where these formations crop out. Recent studies in northern Illinois and southern Wisconsin have shown, however, that recharge to these deep aquifers takes place locally in areas where the hydrostatic head in the water table aquifers exceeds the head in the confined aquifers. Water recharging the deep aquifers moves downward through hundreds of feet of overlying strata in many places throughout the area where the Galena Dolomite or older formations form the uppermost bedrock surface (Foley and Smith, 1954, p. 231; Suter et al., 1959, p. 59) and where such head differential exists.

The stratification and variation in texture of the sedimentary deposits underlying Winnebago County result in changes in permeability in the direction normal to stratification. Because the more permeable water-bearing rocks generally lie between deposits of lower permeability, water in the more permeable deposits is more or less confined under hydrostatic pressure and artesian conditions predominate in the aquifers. Because the confining layers do transmit ground water, although necessarily at a lower rate, ground water moves to and from aquifers in response to the pressure difference involved. If the hydrostatic head in the artesian aquifer exceeds the hydrostatic head in the confining bed, water moves from the aquifer toward the confining bed. If, however, the hydrostatic

head in the confining bed exceeds the hydrostatic head in the artesian aquifer, water moves toward the aquifer.

Water-table aquifers occur in areas where permeable glacial deposits immediately underlie the land surface and in the upland areas where the top of the zone of saturation lies within the Paleozoic bedrock.

#### GEOHYDROLOGIC UNITS

The geologic formations of Winnebago County and their water-bearing properties have been described. On the bases of character and origin of the deposit, stratigraphic position, water-bearing properties, and utilization, these rocks also can be grouped into two general geohydrologic units—glacial drift aquifers and bedrock aquifers. The bedrock aquifers can be further classified as Ordovician aquifers (subdivided into dolomite aquifers and sandstone aquifers) and Cambrian aquifers.

#### GLACIAL DRIFT AQUIFERS

The relatively coarse-textured unconsolidated sands and gravels deposited principally as glacial outwash constitute the aquifers of Pleistocene age. Glacial outwash related to several ice advances occurs within the county, but the deposits associated with glacial activity during the Farmdale substage appear to be thickest, most extensive, and most widely used as aquifers.

Ground water in the glacial drift aquifers occurs under a variety of hydrologic conditions. In areas where coarse-textured permeable deposits are at or very near land surface, ground water may occur under water-table conditions. Where permeable deposits lie beneath the top of the zone of saturation and are overlain by relatively impermeable deposits, artesian conditions prevail. Because of the extremely varied character of glacially derived sediments, the deposits that function as confining layers have a wide range of permeability. As a consequence, leaky artesian conditions are common.

In an earlier study of the chemical quality of water from the glacial drift aquifers (Smith and Larson, 1948, p. 23-26) it was

exceeds the hydraulic head of the aquifer, water

in areas where the water table is immediately underlain by the upland zone of saturated bedrock.

#### UNITS

of Winnebago County. The varying properties of the glacial drift deposits, stratified by varying properties, also can be used by geohydrologists and bedrock aquifers can be further defined in aquifers (subglacial, glacial, and glacial drift) and sandstone and sandstone aquifers.

#### AQUIFERS

Glacial drift aquifers are unconsolidated and deposited principally in the valleys. Glacial outwash aquifers occur with the deposits associated with the Farmdale glacial drift, most extensive as aquifers.

Glacial drift aquifers of hydrologic importance are coarse-textured or very near land surface and may occur under the zone of saturation. Where permeable, they may occur in the zone of saturation. In the Pleistocene conditions, they are extremely varied in character, derived from glacial drift, as confining layers, and permeability. As in the Pleistocene conditions

the chemical quality of the glacial drift aquifers (p. 23-26) it was

concluded that the waters were of two distinct chemical types. The water defined as being from "pre-Wisconsin drift" (probably Farmdale and younger)\* deposits is characterized by 1) an iron content greater than 0.3 parts per million (ppm), 2) hardness greater than 300 ppm, 3) sulfate content less than 20 ppm, and 4) chloride and nitrate content less than 3 ppm.

The second class of water occurring within the glacial drift was classified as local recent recharge waters from rainfall or river infiltration passing through loess and loam deposits. These waters are characterized by 1) nitrate content generally greater than 10 ppm, 2) hardness greater than 400 ppm, 3) sulphate content greater than 50 ppm, 4) chloride content greater than 20 ppm, and 5) iron content less than 0.4 ppm.

The sand and gravel aquifers are limited chiefly to the valley areas where the thickness of the glacial drift is greatest (fig. 8). The large volumes of meltwater discharged into these valleys deposited large quantities of sand and gravel, silt, and clay that nearly filled the valleys and, in some areas, formed extensive aquifers of high permeability. The nature and distribution of the valley-fill materials are related chiefly to the orientation of the valleys in relation to the direction of ice movements and the various positions of the ice fronts.

Where valleys such as the Rock Valley, and probably Troy Valley, served as drainageways that carried meltwater away from the ice fronts, coarse-textured and permeable deposits of sand and gravel outwash constitute a large part of the valley fill. Where the normal direction of drainage in the valleys was toward the ice front or where streams were ponded, as in the Pecatonica and Sugar Valleys, a large part of the valley fill consists of backwater silt and fine sand of relatively low permeability.

\*As the bulk of the valley fill in the Rockford area is outwash associated with the Farmdale glaciation, the water classified by Smith and Larson as pre-Wisconsin probably is associated for the most part with Farmdale deposits.

†In this report the terms Pecatonica Valley, Rock Valley, etc., refer to the older valleys eroded prior to glaciation of the region. The terms Pecatonica River Valley, Rock River Valley, etc., refer to the present land surface valleys in which there are streams or rivers.

#### Aquifers in the Rock Valley†

Large supplies of ground water, such as are required for municipal and industrial purposes, are found in the Rock Valley. In most of the valley area, the coarse-textured outwash is more than 100 feet thick and large capacity wells are developed at depths of less than 300 feet. Permeable outwash deposits commonly extend to land surface, allowing rapid recharge from surface streams and precipitation where water levels have been lowered sufficiently by pumping.

In most of the Rock Valley the extensive and permeable aquifers are undeveloped. Only in the vicinity of Rockford has there been any concentrated development by large capacity wells. The city of Rockford has used these aquifers since 1947 when testing of city well 7A (WIN 44N1E-36.6E) gave a specific capacity of 72 gallons per minute per foot of drawdown, which is 3 to 5 times greater than that of the deep sandstone wells (Smith and Larson, 1948, p. 22).

The principal glacial aquifer for industrial and municipal water supplies in the Rockford-Loves Park area consists of extensive, continuous deposits of coarse-textured valley-train outwash that occurs in the basal part of the valley fill. The upper part of the valley fill, generally above an elevation of 625 feet, is somewhat less uniform. In the vicinity of Loves Park and the till spur at Rockford, the outwash in the upper part of the valley fill is generally finer grained than that in the basal part, although it does contain sand beds of sufficient permeability to supply water for domestic and other wells of small demand. The highest capacity wells generally are developed in the basal part of the valley fill and range from 150 to 300 feet deep. South of the till spur, the upper part of the valley fill is generally coarser textured than the deposits north of the spur, but the highest capacity wells here, too, are developed in the basal part of the valley fill.

The small amount of information available for the area north of Rockford and Loves Park indicates that the upper part of

the valley fill becomes generally coarser to the north. The drillers log of the Wisconsin Power and Light Company well no. 3 (WIN 46N2E-5.7d) provides a description of generally coarse-to-fine gravel above a depth of 122 feet. Below this depth the outwash material contains interbedded coarse gravel, sand, and "shale" (probably clay or silt) to 225 feet. This well is within the deep channel of the valley near the north line of the county.

Well WIN 46N2E-28.7h was drilled through the following sequence of materials.

Warner Electric Brake and Clutch Company plant no. 2 well (WIN 46N2E-28.7h) drilled in 1956 by J. H. Allabaugh, Rockford. Total depth 96 feet. Elevation 755 feet, estimated from topographic map. Correlated drillers log.

	Thickness (ft)	Depth (ft)
Pleistocene Series		
Top soil and fill	5	5
Sand and gravel	30	35
Sand and medium gravel	38	73
Gravel and fine sand	9	82
Sand and pea gravel	6	88
Large stones and gravel	8	96

According to the drillers report, 18 feet of 100 slot, 10-inch diameter screen bottoming at 97 feet was set in the well and during an 8-hour pumping test the well was pumped at a rate of 670 gpm with a draw-down of 18 feet, nine inches from a static level at 34 feet. This shows that in the northern part of the Rock Valley there is a good probability of developing wells of medium to high capacity at depths of less than 150 feet.

Discharge in the tributary valleys along the eastern side of the Rock Valley was, for the most part, away from the ice. These valleys are therefore more likely to contain thick, continuous deposits of permeable sand and gravel outwash than are the tributary valleys on the western side of the Rock Valley.

The following well records indicate the nature of the material filling a tributary valley on the eastern side of the northern part of the Rock Valley about 4 miles east and 2 miles south of Rockton:

WIN 46N2E-26.8a. Elevation 840 feet, estimated from topographic map. Total depth 70 feet.

	Thickness (ft)	Depth (ft)
Pleistocene Series		
Sand and gravel	70	70

WIN 46N2E-27.1a. Elevation 840 feet, estimated from topographic map. Total depth 145 feet.

	Thickness (ft)	Depth (ft)
Pleistocene Series		
Dirt	20	20
Sand and gravel	125	145

Tributary valleys on the western side of the Rock Valley are likely to be filled with glacial till or fine-textured alluvium. This is indicated by the following record of a well drilled in a large tributary valley that enters the ancient Rock Valley northwest of Loves Park.

G. C. Brown well (WIN 45N1E-36.8d). Elevation 730 feet, estimated from topographic map. Drilled 1910. Total depth 128 feet.

	Thickness (ft)	Depth (ft)
Pleistocene Series		
Soil	10	10
Blue clay	115	125
Gravel	3	128

Locally the fill in the western tributary valleys may contain considerable thicknesses of sand and gravel, such as that at the site of well no. 1 of the Atwood Vacuum Machine Company.

Atwood Vacuum Machine Company well no. 1 (WIN 44N1E-11.1c) Elevation 745 feet, estimated from topographic map. Drilled by Varner Well Drilling Company, 1943. Total depth 709 feet. Illinois State Geological Survey sample set 10832. Studied by M. P. Meyer.

	Thickness (ft)	Depth (ft)
Pleistocene Series		
No samples	30	30
Sand and granular gravel, yellow, clean	53	83
Gravel, coarse, clean	7	90
Gravel and sand, slightly silty	15	105
Gravel, coarse, clean	10	115
Sand, yellowish buff, very silty	10	125
Sand and granular gravel, white to yellow, silty	15	140
Till, calcareous, brown	15	155
Sand and gravel, buff, silty	25	180
Sand, buffish yellow, silty	35	215
Clay, yellowish buff, sandy, silty	4	219
Gravel, yellow	6	225
Bedrock below		

on 840 feet, estimated  
depth 70 feet.

Thickness (ft)	Depth (ft)
70	70

on 840 feet, estimated  
depth 145 feet.

Thickness (ft)	Depth (ft)
20	20
125	145

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Valley northwest

(E-36.8d). Elevation  
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Thickness (ft)	Depth (ft)
10	10
115	125
3	128

western tributary  
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Thickness (ft)	Depth (ft)
30	30
53	83
7	90
15	105
10	115
10	125
15	140
15	155
25	180
35	215
4	219
6	225

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The restricted extent of these deposits is indicated by the log of the W. F. and John Barnes Company well (WIN 44N1E-11.1b), located just south of the Atwood Vacuum Machine Company well no. 1, which shows the glacial fill to be 145 feet thick and to consist predominantly of glacial till with minor thicknesses of clean sand and gravel.

#### Aquifers in the Pecatonica and Sugar Valleys

Throughout most of the glacial history of Winnebago County the drainage in the Pecatonica and Sugar Valleys was ponded by the various glacial advances and the large volumes of glacial meltwaters that were being discharged down the Rock Valley. As a result, these valleys contain a large proportion of fine-textured sediments.

Although the valley fill in the eastern part of the Pecatonica Valley attains a maximum thickness of more than 200 feet over the deepest part of the channel, most of the fill is from 100 to 200 feet thick (fig. 8). The character of the valley fill near the junction with the ancient Rock Valley is indicated by the following well record.

Fred Wieland well (WIN 46N1E-13.4c) drilled 1948 by Bloyer and Dennis, South Beloit. Total depth 230 feet. Elevation 750 feet, estimated from topographic map. Correlated drillers log.

	Thickness (ft)	Depth (ft)
<b>Pleistocene Series</b>		
Coarse gravel . . . . .	15	15
Fine sand . . . . .	65	80
Sand and clay . . . . .	80	160
Fine sand . . . . .	45	205
<b>Ordovician System</b>		
St. Peter Sandstone		
Sandstone, brown . . . . .	25	230

The preponderance of fine sand and the lack of coarse-textured deposits reported in the above well log indicate that the deposits in the Pecatonica and Sugar Valleys are in general likely to yield less water than the thick, coarse-textured deposits that characterize the Rock Valley.

Locally, coarse-grained deposits are found in the Pecatonica and Sugar Valleys. The following partial log of the Atwood Fish

Farm well no. 2 (WIN 27N11E-6.4e) shows the beds of clean, coarse-textured sand and gravel in the Pecatonica Valley.

Atwood Fish Farm well no. 2 (WIN 27N11E-6.4e) drilled June 1944 by Varner Well Drilling Company. Total depth 606 feet. Elevation 728 feet, estimated from topographic map. Illinois State Geological Survey sample set 11202. Studied by M. P. Meyer.

	Thickness (ft)	Depth (ft)
<b>Pleistocene Series</b>		
Silt, dark brown, coarse, micaceous, non-calcareous . . . . .	15	15
Silt, brown, micaceous with fine quartz and sand grains . . . . .	10	25
Sand, brown, very fine to coarse, very silty . . . . .	5	30
Sand, quartz and dolomite grains, buff, fine to coarse, clean . . . . .	15	45
Sand and little gravel, clean . . . . .	15	60
Clay, calcareous, brown, carbonaceous . . . . .	25	85
Silt, sandy, calcareous, brown, carbonaceous, micaceous . . . . .	10	95
Clay, sandy, calcareous, brown . . . . .	10	105
Sand, calcareous, brown, medium, very silty . . . . .	5	110
Clay, calcareous, brown, micaceous, with few sand grains . . . . .	20	130
Sand, white, medium to coarse, clean . . . . .	4	134
Gravel, coarse . . . . .	9	143
Sand, quartz and dolomite, buffish yellow, fine to medium, very silty at top . . . . .	32	175
Sand, white, medium to coarse, few dolomite grains; chert, white, brownish yellow coating . . . . .	5	180

Coarse-textured outwash suitable for ground-water development may be widespread throughout the Pecatonica and Sugar Valleys or may occur only in local beds or lenses of limited extent. Sufficient subsurface information upon which to base a detailed description of the character, sequence, or distribution of the valley-fill deposits or to evaluate their water-yielding character is not available over a large area in the valleys.

Deposits in the tributary valleys of the Pecatonica and Sugar Valleys consist principally of fine-textured material like that in the major valleys. However, they locally contain coarse-textured outwash. Coarse-textured outwash is reported in the drillers record of the Durand Village well, which is in a large tributary of the Sugar Valley.



## BEDROCK AQUIFERS

The bedrock aquifers are widely used as sources of ground water for all needs. The shallow Ordovician aquifers provide ground water for domestic and smaller municipal and industrial purposes. The deeper lying Cambrian aquifers contain fresh water to a depth of at least 2000 feet below land surface, and wells drilled to them obtain sufficient quantities of water for the largest municipal and industrial requirements.

Smith and Larson (1948, p. 14, 24, 30) recognized little, if any, difference in water levels and water quality among the various bedrock aquifers. For this reason they considered the bedrock aquifers as a single hydrologic unit.

The direction of water movement in the bedrock aquifers in Winnebago County, as determined by a contour map of the piezometric surface, is toward the Rock River from the northwest and the northeast (Smith and Larson, 1948, fig. 3). The piezometric surface indicates that ground water from the bedrock aquifers is being removed from the area by discharge into the Rock River or by underflow through the valley fill.

Studies of water quality indicate that the "normal" sandstone waters of the area are somewhat less mineralized than the glacial drift waters. The sandstone waters are characterized by 1) a hardness less than 300 ppm, 2) iron less than 0.3 ppm, 3) nitrate less than 4 ppm, and 4) sulfate less than 15 ppm (Smith and Larson, 1948, p. 24).

## Ordovician Aquifers

*Dolomite Aquifers*

The Galena, Decorah, and Platteville Formations constitute the uppermost bedrock throughout most of the county (fig. 10). Because of their wide extent, their relatively shallow depth, and consistent water-yielding zones, these formations provide water to more wells than any other geohydrologic unit in the county. Of a total of 560 well records used in this study, 244, nearly 44 percent, are of wells completed in these dolomite aquifers. Samples

of drill cuttings were available for study from 80 wells in the county and of this total 28 wells were finished in the Galena Dolomite, 18 in the Decorah Formation, and 34 in the Platteville Dolomite. Considering the extent and thickness of the formations involved, the distribution indicates that the aquifer characteristics of the three formations are similar and that they may be classified as a single geohydrologic unit.

Ground water may occur under water-table conditions in areas where the upper surface of the dolomite occurs above the zone of saturation. This condition is common in the upland areas where the dolomites are overlain only by thin deposits of glacial drift. Where water-yielding crevices in the dolomites are encountered deep below the top of the zone of saturation the ground water generally occurs under artesian conditions.

A depth-frequency analysis of 216 wells drilled into the dolomite aquifers shows (fig. 11) that approximately 84 percent of the wells penetrate up to 100 feet of dolomite. Only 10 percent of these wells penetrate less than 20 feet into the dolomite. The average depth of the dolomite wells is 104 feet and the average depth of penetration into the dolomite for water supplies is 71 feet, indicating that the average thickness of cover over the dolomite is about 33 feet. Therefore, it appears reasonable to assume that in the area underlain by the dolomite aquifers of Ordovician age the majority of the wells to be drilled for domestic, stock, and other small water supplies will penetrate from 20 to 100 feet into dolomite to obtain the required amount of water.

The consistent occurrence of water-yielding zones in the dolomite and the narrow range of depth of penetration into dolomite suggest that the water-yielding character of the dolomite aquifers is a result of a well developed joint and fracture system. In other studies it has been noted that where the Galena-Platteville interval is overlain by the Maquoketa Shale, the dolomite is a less favorable source of ground water than in areas where it is exposed at land surface or overlain by glacial drift (Drescher, 1953,

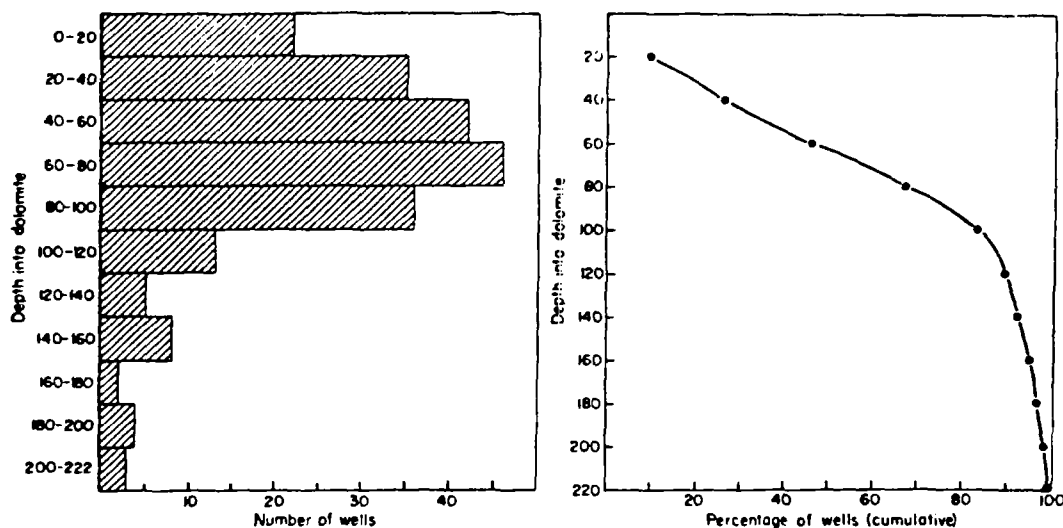


FIG. 11.—Histogram and cumulative percentage curve of wells penetrating to various depths into dolomites of the Galena, Decorah, and Platteville Formations in Winnebago County.

p. 9; Foster, 1956, p. 29). The over-all transmissivity of the dolomites depends more upon joints and fractures than bedding planes.

Solution activity has undoubtedly played an important secondary role by enlargement of the joints and fractures but apparently has not progressed sufficiently to develop areas of cavernation, which would produce extreme variability in the water-bearing properties of the dolomites.

In dense limestone and dolomite formations, underground water moves through relatively open channel ways in which there is little, if any, filtering action. As a consequence, water in these formations is more susceptible to pollution and contamination than water in granular materials like sand.

The susceptibility of dolomite aquifers in glaciated areas to bacterial pollution is related in part to the thickness and character of the unconsolidated material that occurs above the dolomite and between it and the source of pollution. To provide adequate filtration, a fine-textured material of low permeability, such as clayey glacial till, need not be as thick as a coarser textured, more permeable material. Where the material is very coarse textured, as, for instance, gravel, the intergranular openings

may be so large that they are relatively ineffective in the filtration of bacteria, and protection of the underlying dolomite is dependent principally upon the relative position of the top of the zone of saturation and the direction of ground-water movement.

General standards recommended for the necessary thickness of cover between the source of pollution and the top of the dolomite to afford protection from bacterial pollution of wells in limestone and dolomite areas have been adopted by the Illinois Department of Public Health. In closely populated areas, such as suburban developments, a minimum thickness of at least 50 feet of glacial drift must overlie a limestone or dolomite aquifer if private water supplies are to be used from this aquifer without chlorination. Where water supplies for municipal purposes are to be obtained from near-surface limestone or dolomite aquifers, at least 100 feet of glacial cover must overlie these aquifers. Where pollution is known to exist in the aquifers, chlorination treatment is necessary, regardless of the thickness of drift cover.

For adequate protection in sparsely populated areas, a minimum thickness of 30

feet of clayey glacial till is necessary between the lowest point of potential sources of pollution (such as privy vaults, cess-pools, tile in seepage systems, excavations, and abandoned wells) and the top of the limestone or dolomite within a radius of one-fourth of a mile from the well. The installation of leaching types of private waste-disposal facilities are not recommended where less than 30 feet of clayey glacial till is present between the surface of the limestone or dolomite and the lowest point of the source of pollution.

Because polluting bacteria tend to float on or near the top of the zone of saturation, the injection of cement grout between the casing and the limestone or dolomite from the surface to at least 15 feet below the maximum drawdown level, may, along with continuous adequate chlorination of the water supply, provide adequate protection.

In Winnebago County there are extensive areas within which the dolomite aquifers of Ordovician age are overlain by less than 50 feet of glacial cover (fig. 8). The glacial deposits overlying the dolomites consist largely of till of Farmdale age that has a matrix characterized by low clay content and is classified as a silty sand. Such material is likely to have a higher than average permeability for glacial till and to require greater thickness for effective filtration of polluting bacteria. Locally, the thin glacial cover may contain only highly permeable sand and gravel deposits that afford little protection from movement of bacterial pollution into the underlying dolomite aquifers.

#### *Sandstone Aquifers*

In Winnebago County the basal rocks of Ordovician age, including the St. Peter Sandstone and the lower part of the Glenwood Formation, form a geohydrologic unit that is widely used as a source of ground water. This unit is characterized by permeable, relatively uniform lithology and is continuous throughout most of the area. The shales and dolomites of the upper part of the Glenwood Formation are not known to be water-yielding in Winnebago County

and, where present, separate the sandstone aquifers from the overlying dolomite aquifers.

The sandstone aquifers are believed to underlie the entire county, with the exception of the extreme northern part of the ancient Rock Valley (fig. 10) where the base of the valley probably penetrates the underlying Trempealeau Dolomite. Throughout most of the county stock and domestic wells can be developed economically within the upper 50 feet of the unit.

Unlike the overlying dolomite aquifers, the sandstone aquifers satisfactorily supply enough water for smaller municipalities, subdivisions, public institutions, parks, and several industries that have water requirements generally less than 300 gpm. Of the total number of well records used in this study, 71 were of wells that obtained water principally or entirely from the sandstone aquifers of Ordovician age.

In Winnebago County the sandstone aquifers are for the most part overlain by dolomites of the Galena, Decorah, and Platteville Formations or by relatively thick deposits of glacial drift (fig. 10) and the water in the sandstone aquifers is generally artesian. Water-table conditions occur in the sandstones only in the limited areas where they are exposed at land surface or are overlain by a thin cover of glacial deposits.

Along the Rock Valley north of Rockford, the hydrostatic pressure in the sandstone aquifers is somewhat greater than that in the overlying gravel (Smith and Larson, 1948, p. 18) and water from the sandstone aquifers is discharged into the glacial drift with which it is in contact. Within the Rockford area, pumpage from the sandstone aquifers has developed cones of depression within which hydrostatic pressure in the bedrock aquifers is less than that of the overlying glacial drift and local recharge of the sandstone aquifers from the overlying gravels apparently occurs (Smith and Larson, 1948, p. 18).

In the Pecatonica River Valley, discharge from the sandstone aquifers is retarded by the relatively tight valley fill. Locally, as at the Atwood Fish Farm, hydrostatic pres-